

Inducing systemic hyperkalemia for cardiac arrest during cardiopulmonary bypass with patent cardiac circulation

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ABSTRACT

In any cardiac patient, efforts should be made to avoid volume overload, especially around the time of surgery. Continuous retrograde Del Nido cardioplegia, a common practice for maintaining cardiac arrest during a procedure when a patient has patent circulation, has the unintended side effect of significantly adding to the net fluid infused into the patient. Systemic hyperkalemia has been induced to reduce the amount of cardioplegia needed to maintain cardiac electromechanical arrest. To supplement knowledge regarding this technique, we report our experiences using systemic hyperkalemia in the context of the use of Del Nido cardioplegia.

KEYWORDS Cardioplegia; cardiopulmonary bypass; Del Nido cardioplegia; hyperkalemia; redo cardiovascular surgery

Collateral coronary blood flow can adversely affect myocardial protection in patients undergoing cardiac surgery. In redo sternotomy procedures, the presence of a patent left internal mammary artery can prevent the heart from maintaining electrical cardiac arrest during the procedure.¹ Currently, most methods of maintaining cardiac arrest require continuous retrograde cardioplegia throughout the case. Although effective, the use of continuous retrograde cardioplegia causes serious hemodilution, which leads to increased bleeding and volume overload.² Inducing systemic hyperkalemia has been attempted to reduce the amount of cardioplegia needed to maintain cardiac electromechanical arrest.³ We report our experiences using systemic hyperkalemia to maintain electrical cardiac arrest during these types of procedures.

CASE SUMMARY

For two patients needing cardiac valve replacements, cardiac catheterization was performed, which demonstrated prior complex multivessel coronary artery disease with patent grafts. Redo sternotomy was performed. Cardiopulmonary bypass was initiated via cannulation and the patients were cooled to 25°C. Antegrade and retrograde Del Nido cold

cardioplegia was administered to achieve a diastolic arrest, the aorta was cross-clamped, and cardiac valve replacement(s) was performed. Both patients had a live left internal mammary artery (LIMA), and a “no-touch” technique was utilized to avoid isolation. Potassium (80 mEq) was administered to achieve a systemic potassium of 6.5 mmol/L to augment our ability to maintain electromechanical arrest during the case despite the live LIMA graft. Cardioplegia was dosed approximately every 45 minutes to ensure adequate myocardial protection. During the cross-clamp time, two subsequent doses of 20 mEq of potassium chloride were given to maintain a serum potassium level of 6.5 mmol/L. Prior to removing the aortic cross-clamp, the perfusionist utilized zero-balance ultrafiltration, and the anesthesiologist administered insulin and glucose to achieve a serum potassium close to 5 mmol/L. Both cases required inotropic support after surgery, and the postoperative courses were uneventful.

Table 1 shows relevant differences between the two cases. Notably, case 1 had severe aortic stenosis with an aortic valve area of <0.9 cm² and mild aortic insufficiency. Case 2 was more complex, presenting with a dilated left ventricle, mixed ischemic and valvular cardiomyopathy, left atrial enlargement with severe aortic insufficiency, and moderate to severe mitral insufficiency. In case 1, bypass was instituted with the

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Table 1. Clinical characteristics of two patients in which systemic hyperkalemia was used to maintain electrical cardiac arrest

Variable	Case 1	Case 2
Age (years)	75	73
Sex	Male	Female
First cardiac operation	CABG (age 72)	CABG, AVR, MVR, TVR (age 68)
Latest cardiac operation	AVR	MVR + AVR
Ejection fraction before surgery	65%	30%
Del Nido cold cardioplegia	+ (to 25°C)	+ (to 25°C)
Potassium given (mEq)	80	80
Frequency of cardioplegia (min)	q45	q45
Cardiopulmonary bypass time (min)	141	161
Aortic cross-clamp time (min)	101	114
Post-completion serum K ⁺ (mmol/L)	5.2	4.2
Postoperative hospital stay (days)	6	7

AVR indicates aortic valve replacement; CABG, coronary artery bypass grafting; MVR, mitral valve replacement; TVR, tricuspid valve replacement.

right axillary artery and central venous cannulation, and a cross-clamp was placed with careful dissection despite dense adhesions in the aortopulmonary window. In case 2, bypass was initiated with mid to distal aortic arch cannulation and bicaval venous cannulation.

DISCUSSION

Systemic hyperkalemia provides myocardial protection evenly throughout the heart without the fear of having the cardioplegia “washout.” The goal is to provide a quiescent and bloodless surgical field for the surgeon. An alternative

would be to administer continuous retrograde. As the cardioplegia gets washed out from the blood of the patent LIMA, new cardioplegia is present to rearrest and/or maintain cardiac arrest. There are many disadvantages to this approach, notably the hemodilution that takes place with continuous retrograde cardioplegia.² Yet another alternative is obtaining a ventricular fibrillation arrest, which still causes hemodilution, prevents a quiescent and bloodless field, and does not provide a complete electromechanical arrest. With the systemic cardioplegia approach, the “washout” blood coming from the patent LIMA contains a high level of potassium, which maintains the electromechanical arrest of the heart. Nearing cross-clamp removal, the process of zero balance ultrafiltration and administration of glucose and insulin can be used to lower the systemic potassium back down close to 5 mmol/L. The ease of administering systemic potassium to achieve and maintain cardiac arrest as well as the ease of removal of excess potassium with the above-described techniques simply solves the problem of operations with the presence of a patent LIMA graft. Although we highlight the use of systemic hyperkalemia in the setting of a “live” LIMA, this protocol can be a part of a surgeon’s repertoire in other intraoperative conditions such as an unclampable or “porcelain” aorta.

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